Quality of data collected through the use of camera traps at a number of sites frequented by otters within Cork City.

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CARL Research Project
in collaboration with
Cork Nature Network

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- provide their services on an affordable basis;
- promote and support public access to and influence on science and technology;
- create equitable and supportive partnerships with civil society organisations;
- enhance understanding among policymakers and education and research institutions of the research and education needs of civil society, and
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Abstract
Camera trapping is now a very popular method in ecology. It has several recognised limitations, however it is expected with improved methodologies and technology these constraints will lessen. The quality of data collected regarding otters and in general is often questioned. This study aims to assess the usefulness of the data obtained from camera trapping and to provide a framework for using camera traps in urban riparian environments and also to gauge the otter presence in the area. Several other important species were also identified such as the invasive American mink and many birds. The study site is due to under go large scale flood protection measures namely in the form of a large culvert. This study will thus be part of a larger study to examine the overall effects from these measures. Camera trapping was used as otters are a nocturnal, elusive species. Four sites were chosen based on preliminary studies. It was seen that otters are actively using this river mostly at night. Two areas of high use were identified and a suggested area that could be a feeding ground was recommended for future study. A lack of information on the value of mitigation effects was also identified and is a very important area for future research. (WC 208)

Acknowledgments
I would firstly like to thank my supervisor Thomas Quirke for his contribution throughout the project and providing a camera. Secondly I would like to thank Cork Nature Network (CNN) and its members Karen Loxton, Chris Moody, and Gill Weyman for their constant support and expertise throughout providing invaluable information regarding the study site and for providing the remaining cameras. Lastly I would like to thank Cork Academic research links (CARL) and William O' Halloran for facilitating this project.

Introduction
Camera trapping is becoming an increasingly popular method in ecology particularly with regards to mammals (Burton, et al., 2015). It is now a well-established method of studying animal ecology and has been used to estimate population density both with (Carbone, et al., 2001) and without (Rowcliffe, et al., 2008) identifying individuals. Camera trapping was first present in the literature in the 50s. When infrared camera systems became available it became much more common (Cutler & Swann, 1999). Today, PIR (passive infrared triggered) cameras are the most commonly used type They work by sensing a quick change in thermal energy.

Although many studies have misreported how they work which potentially leads to incorrect conclusions and therefore it is important to establish that the camera passively monitors the temperature and when a sufficiently quick change occurs, either an increase or decrease in this temperature the camera is triggered (Welbourne, et al., 2016). Camera traps have been shown to have very little impact on the study species (Findley, et al., 2017) making them very favourable as a non-invasive method to study nocturnal and elusive species (Cutler & Swann, 1999) (Swann & Perkins, 2014). The majority of camera traps used today are small, one unit, digital and are triggered using an infrared light source with data usually being image(s) or videos of animals. This data can be used to study behaviour, feeding events and to identify species and individuals. There are many advantages of using camera traps. Camera trapping has been shown to be a better method than live traps and sign sampling to measure biodiversity and is proven to be a cheaper also (Molyneux, et al., 2017). Is it useful in replacing human surveys where observers remain in place and for counting animals at night. Advantages over people include minimising bias, consistency and hard copy images for later analysis and can ultimately go towards management plans (Stratford & Naholo, 2017).

Lutra lutra is the most common otter species throughout the world with populations in the whole of Europe, Asia and North Africa (Hung & Law, 2016). They are solitary, mainly feeding on fish. They are most active during the night in freshwater habitats. This is thought to be due to a higher prey availability at night. (Kruuk, 2006) Nocturnal behaviour has also been attributed to air temperature and season (Quaglietta, et al., 2018). They are believed to perform best in areas of high riverine vegetation as this offers cover (Pedroso, et al., 2014). Irish Eurasian otters mostly feed on fish (O' Leary, et al., 2006), (Preston, et al., 2006) and favour river systems with salmonids that are non-homogenous and/or wide and large (Reid, et al., 2013). They are affected by the physical properties of their environment and seem reasonably tolerant to differences in water quality (Reid, et al., 2013). They are no longer seen as a bio-indicator of good water quality due to here opportunistic feeding (Reid, et al., 2013). In Ireland males and females occupy intra-sexual home ranges with male home ranges being largely affected by conspecifics (O' Neill, et al., 2009). Distribution of females tends to be controlled by the resident adult female and these home-ranges are inversely related to river width indicating a relation between home range size and foraging areas. Adult males ranges are somewhat unstable - if a neighbouring male dies the remaining male will quickly take over his home range (O' Neill, et al., 2009). Otter species have been shown to exhibit minimum disturbance to camera trapping, in that they don’t overly investigate the camera and visits to check the cameras have been shown to not affect the time it takes for an otter to revisit a site (Pickles, et al., 2011) (Findley, et al., 2017) and as they are elusive, nocturnal species (Kruuk, 2006) they are a suitable study species for camera trapping. Camera trapping has been used to confirm otter holts with a dual-camera set up (Findley, et al., 2017), their presence and basic ecology (Karamanlidis, et al., 2014), to quantify ranges (Joshi, et al., 2016), identify activity patterns (Garcia de Leaniz, et al., 2006) and activity patterns of giant otter (*Pteronura brasiliensis*) (Leuchtenberger, et al., 2013) and to examine the use of spraint investigations (Guter, et al., 2008).

There are several well-known problems associated with camera trapping. It is very difficult to eliminate bias in that camera placement directly affects the data obtained and small-scale features can have a significant effect and if the presence of certain features should be noted (Kolowowski & Forrester, 2017). For example, in the study of otters *Lutra lutra* a camera outside a holt would most likely obtain more footage then a camera placed completely at random. Also, problems occur with human error, environmental problems and equipment (Stevens, et al., 2004). Lost equipment from theft and damage can also be an issue. It is relatively easy for animals to pass undetected either travelling in the water or behind the camera without triggering the sensor. For this reason, they don't give accurate population assessments (Hönigsfeld-Adamič & Smole, 2011). There have been some instances where camera traps were ineffective in capturing otter's for unknown reasons but were successful for similar species such as mink (González-Esteban, et al., 2004). Some studies have shown them to be highly inefficient. One such study using odour baits found no otters in 150 days with a PIR sensor where as another camera was set up with an odour bait and caught an otter in 2 days (Lerone, et al., 2011). Despite these shortcomings, it has been hypothesised that because of advances in technology camera traps have improved significantly. Many studies have used low-end cameras or not enough cameras and therefore these studies may not be representative of what can be done today (Day, et al., 2016).

Urban ecology is becoming an increasingly large field as more animals are being forced either by better food resources of better habitat to move into cities. It is likely that otters are also following this trend in Ireland (Sleeman & Moore, 2005), (White, et al., 2013) However urbanisation brings on new challenges for otters. One such challenge is flood management. Dam building has been shown to bring about a decrease in otter presence and changes in range due to areas no longer being suitable for otters. It also changes their diet which is subsequently made up of more non-natives and a drop in overall fish diversity. Dam construction also damages resting and feeding sites (Pedroso, et al., 2014). Canalisation reduces biodiversity and leads otters to prey on poorer food sources like amphibians. (Kloskowski, et al., 2013). Flood management on rivers can cause a reduction in structural diversity, biodiversity and biomass. That being said structures such as bridges, weirs, canals are not avoided by otters. Otters have been shown to be efficient at recolonizing, much otter decline in the UK was associated with the highest populated areas but the recovery of the species doesn't seem to be affected by the presence of humans (Chanin 2003). The Northumberland Biodiversity action Plan for otters involved the creation of log piles and artificial holts near watercourses in habitats that are deemed likely for otters. Also the conservation of features such as older trees, scrubs and overhanging root systems (Jaggs, 2009).

Otters are protected under Annex II and IV of the EU habitats directive (EuropeanCommission, 1992) and currently have a status of favourable in Ireland (Reid, et al., 2013). Otters are known to be active in the study area (Sleeman & Moore, 2005) (White, et al., 2013) mainly feeding on fish such as salmonids and eel *Anguilla Anguilla*, they also feed on common rats *Rattus norvegicus* and birds (O'Leary, et al., 2006). There are flood protection measures planned for the river in the coming years includes culverting the river, putting in a trash screen and building flood defence walls on the banks (Office of Public Works, 2016). To fully understand the extent to which these measures will affect the otters it is necessary to understand fully otter ecology and behaviour in the river at present. The main aim of this study is to assess the quality of data collected through the use of trail cameras to study otters and the potential for it to be used further in other otter studies. However, this study also aims to provide valuable information on the behaviours of the otters in this river and work towards mitigation factors to the proposed flood control measures. Four cameras using passive infrared sensor will be set up along a river in an area of known otter activity (Reid, et al., 2013) (White, et al., 2013) (Sleeman & Moore, 2005). The chosen site was selected due to the proposed flood works which are to be carried out in the area. Similar designs were used by (Pickles, et al., 2011). Lastly this study will provide more of an insight into the problems and solutions to using camera traps in an urban riverine environment. (WC 1491)

Materials and Methods

Background

This study was facilitated by Community Academic Research Links (CARL) with the help of Cork Nature Network who put forward the research topic. They are working to protect otters from the upcoming flood protection measures. CARL is apart of University College Cork and supports civil society organisations working together to carry out research in close connection to students (Bates & Burns, 2012).

Equipment

Five camera in total were used, 4 Browning Dark Ops HD 940 and one Ltl Acorn trail camera. The Ltl Acorn was swapped for a 4 Browning Dark Ops HD 940 as very little data was being collected from it and they were swapped to ensure this was not an issue with the camera, it was not an issue with the camera and therefore the results were in no way effected. Both camera worked by Passive infrared sensor (PIR) which works by detecting temperature gradients.

Study Site

The camera traps were set up in four sites on the lower River Bride in Blackpool, Co. Cork city, Ireland. Table 1. Shows the locations and names of the four cameras at each site.

Table 1 Camera names, GPS locations, points on map and duration for which cameras were functioning.

#	Name	GPS	Point on map	Operational Period	Time (Days)
1	McDonalds	51°55'12.3"N 8°28'54.8"W	1	19 December 2017-13 January 2018	35
2	Pyramid Rock	51°54'51" N 8°28'26" W	2	20 December 2017-18 February 2018	60
3	Large Rock	51°54'50.0"N 8°28'27.1"W	3	8 January 2018-18 February 2018	41
4	Estate	51°54'48.8"N 8°28'27.8"W	4	23 December 2017-13 January 2018	21

The McDonalds site was approximately 1 m above water level, under a bridge in a car park of a retail area adjacent to a national road. The Pyramid rock site was located in a residential area and had significant vegetation and was beside a small pool. These two sites were known to be frequented by otters. The Large rock was also a very natural site and was located just before a large pipe carrying water into the river. Lastly, the Estate site also in a busy residential area was adjacent to a concrete wall and the opposite bank was devoid of any significant vegetation.

The Pyramid rock is 1 km down river from the McDonalds site, the large rock is a further 30 m downriver from the pyramid rock and lastly, the Estate site is 60 m on from the large rock covering a stretch of river totalling 1090m. This can be seen clearly on the map in Figure 1. Winter was a suitable study period as otters have been shown to spraint more often during winter (Kruuk, 2006) which in some places coincides with low prey availability (Kruuk, 1992).

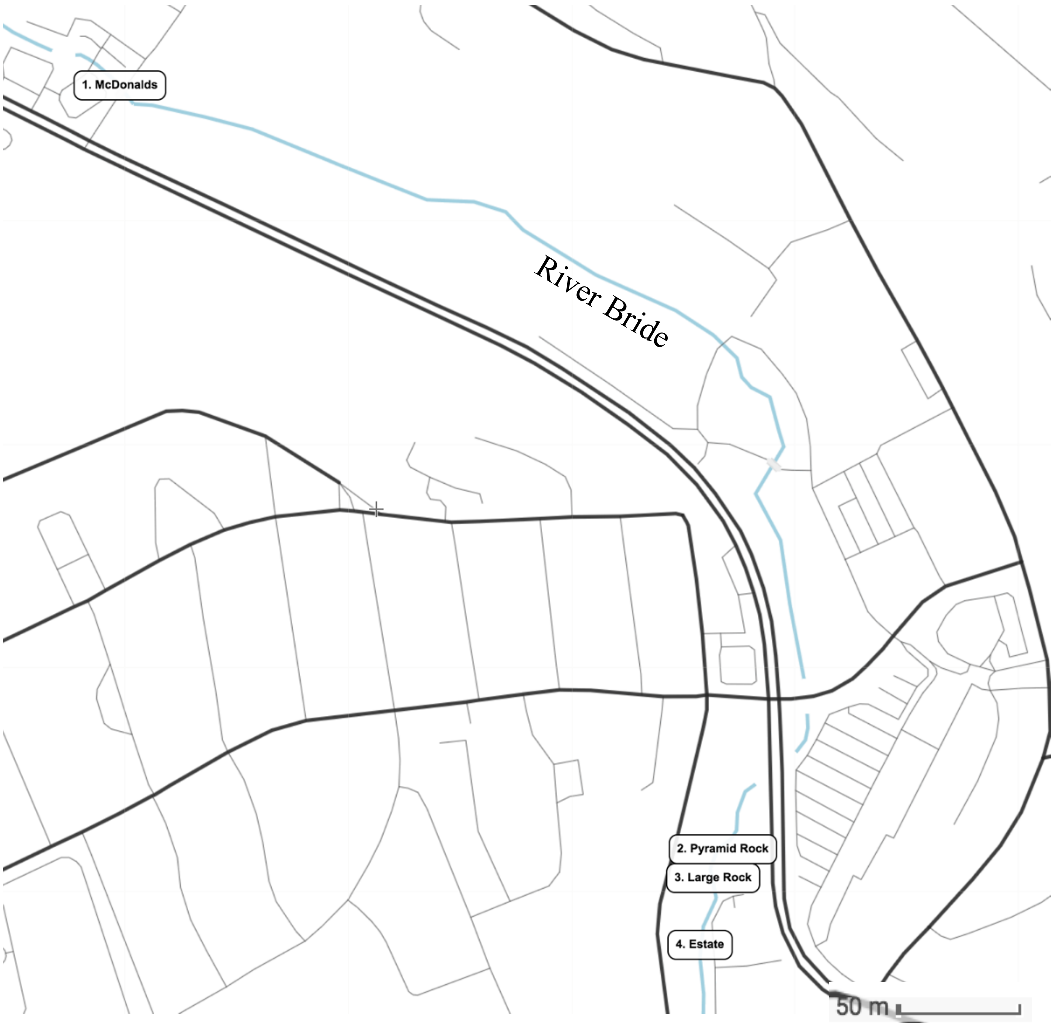

Figure 1. Map of river Bride showing camera site locations and names.

Camera trapping

Site Considerations-Urban Area

Camera trapping has been shown to be a suitable method to study elusive and nocturnal species (Cutler & Swann, 1999). As this was an urban environment there was a constant threat of vandalism and the cameras were set up with this in mind. The cameras had camouflaged cases and were only set up and visited close to dawn in order to decrease the chances of theft and interference. Four cameras were set up on the River Bride in Blackpool. Figure 1. shows the locations of the cameras along the river. Each camera was assigned a name and a number. The study period was from the 19 December 2017 to the 19 February 2018 a total of 62 days.

Site Considerations - Optimisation of Camera Positions

As it would have been impractical to set the cameras up randomly (Kolowowski & Forrester, 2017) they were set up in order to maximise the amount of data collected. Areas of high use were identified from walking the river with members of a local nature group – Cork Nature Network who had carried out previous surveys. Three of the cameras (Pyramid rock, estate and large rock) were set up in an area soon to be culverted and the other (McDonalds) was set up by a national road, the N21 and was situated inside a busy car park. All areas were urbanised and prone to heavy traffic. Two of the cameras were set up in areas known to be frequented by otters. The other two were set up in sites that had a suitable area for otters to be seen. They were checked opportunistically at least once every two weeks early in the morning and the SD cards were removed, uploaded, wiped and reinserted into the cameras and batteries were changed when necessary. Cameras were attached to tree trunks, branches and rocks and no bait was used as not to effect the otters' behaviour.

Video Considerations

The cameras were triggered by changes in temperature and motion. When triggered they were set to record a 30-second video. 30 seconds was chosen as a suitable length because it wasn't too short as to affect data quality nor too long which would drain the batteries and would redundantly increase the time it took to go through all the data (Findley, et al., 2017). They were set to a

Challenges encountered due to bad weather

When it was not possible to enter the water due to flooding they were checked visibly from the bank to ensure they were still in place. At each visit, it was ensured that the cameras were functioning correctly which was evident from the wide variety of species captured at varying temperature and times of the day. Due to the vulnerability of this river to flooding on the 13/01/2018 cameras, 1 and 4 were both submerged and ceased functioning

Data Analyses

All data analysis was carried out in R version 3.3.3. From each video, the temperature, date, time, GPS, species (trigger), number of species, dominant behaviour and time spent in the shot were noted. No effort was made to identify individuals. The total number of species at each site was calculated as was the species diversity using the Shannon-Weiner Index for each site using the following equation:

$$H' = \sum_{i=1}^{s} (p_i)(\ln p_i)$$

A general ethogram for all species was made for the dominant behaviours. Each camera site visit was split into 6 time periods, 10am-2pm, 2pm-6pm, 6pm-10pm, 10pm-2am, 2am-6am and 6am-10am. A visit was characterised by the presence of any species in the shot and a false-positive was defined as no visible species in the shot. Two animals present in one shot was considered two visits. (WC 954)

Results

For the McDonalds site, Table 2. the behaviours present, sprainting and locomotion are spread somewhat evenly in that there is only one behaviour for each time period. Locomotion occurred twice from 10 am - 2 pm and once from 2 pm - 6 pm. Sprainting occurred once between 6 pm - 10 pm and 10 pm – 2 am and twice for the remaining two time periods of 2 am – 6 am and 6 am – 10 am. Otter presence increased from 2 am - 2 pm with double the number of visits compared to 2 pm – 2 am. In contrast the behaviours and visits at the Pyramid Rock and less dispersed throughout the time periods with a concentration of activities between 6 pm - 2 am. These included all four behaviours. Sprainting was observed twice, investigation was observed once locomotion was observed 7 times and vigilance was observed once. A further two otters were caught moving between 6 am - 10 am. Overall, more behaviours were observed at the Pyramid Rock overall and for a smaller amount of time.

Table 2. Different behaviours of otters for each time period according to site.

	Site											
Behaviour	McDonalds						Pyramid Rock					
	10am-2pm	2pm-6pm	6pm-10pm	10pm-2am	2am-6am	6am-10am	10am-2pm	2pm-6pm	6pm-10pm	10pm-2am	2am-6am	6am-10am
Sprainting	-	-	1	1	2	2	-	-	2	-	-	-
Investigating	-	-	-	-	-	-	-	-	1	-	-	-
Locomotion	3	1	-	-	-	-	-	-	3	4	-	2
Alert	-	-	-	-	-	-	-	-	-	1	-	-
Total	3	1	1	1	2	2	0	0	6	5	0	2

Figure 2. shows the average amount of time in shot +/- SD for otters at McDonalds and Pyramid Rock for each time period. More time overall was spent at McDonalds, where otters were present during all time periods for a maximum of 8 seconds (10 am - 2 pm) and a minimum of 5 seconds (2 am - 6 am). Time periods 2 pm - 6 pm, 6 pm - 10 pm,10 pm - 2 am and 2 am - 6 am all had corresponding mean times of around 5 seconds. For the Pyramid Rock site otters were only present during the four time periods of 6 pm - 10 pm, 10 pm - 2 am, 2 am - 6 am and 6 am - 10 am for a mean time of 5 seconds, 3 seconds, 5 seconds and 2 seconds respectively. For the data points where no error bar is shown there was either only one visit or visits were of the exact same duration. This is evident for 3 of the time periods for McDonalds and 1 for the Pyramid Rock. There is overlap for in the error bars in particular for the McDonalds site at 6 am - 10 am the error bar is very large and encompasses all data except for a small proportion of the Pyramid Rock error bar at 6 pm - 10 pm.

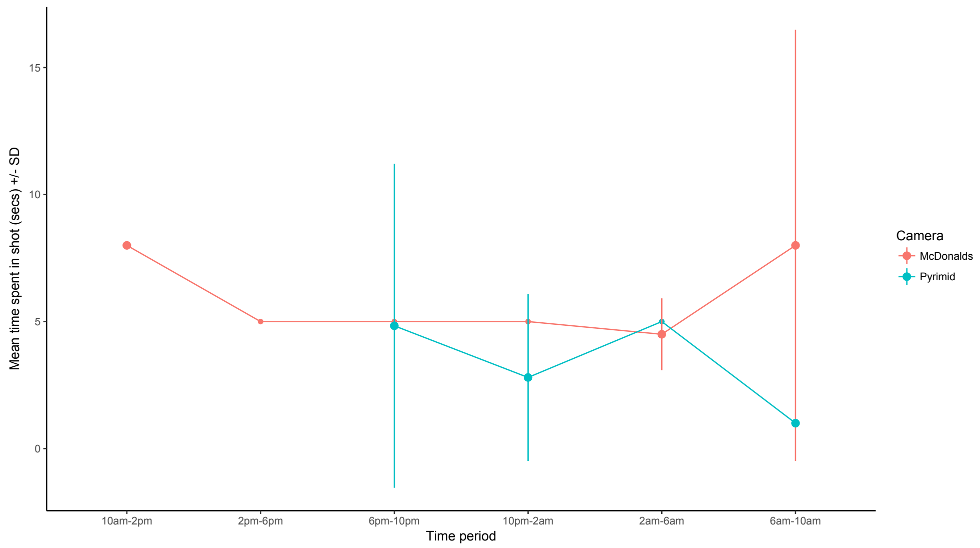

Figure 2. Plot showing mean time spent in shot +/-SD by otters for the six different time periods at each site.

From Table 2. it can be seen that a total of 18 identifiable species, 20 unidentifiable birds and 1 unidentifiable mammal species were recorded by the cameras. Of these 18 species, 3 were mammals which included otters (*Lutra lutra*), rat (*Rattus*) and the american mink (*Neovison vison*). There were also 16 species of bird recorded. The 6 dominant species overall were grey wagtails (*Motacilla cinerea*) (29.1%), dippers (*Cinclus cinclus*) (17.3%), robin (*Erithacus rubecula*) (15.7%), otter (8.2%) and lastly rat (5.5%) and blackbird (5.5%) accounting for a total percentage of 81.3%. The McDonalds site had a total of 11 individuals covering 3 species, all mammals. The Pyramid rock site was predominantly birds (10 species and 3 unidentifiable) and also otter and rat. The Large Rock site contained 3 species, mallard (*Anas platyrhynchos*), rat and blackbird (*Turdus merula*). Lastly, the Estate site contained rat, 8 bird species plus 17 unidentifiable bird species and 1 unidentified mammal.

Table 2. Amount of visits recorded for each species at the four sites along with the Shannon-Weiner diversity index and temperature (°C) for each site.

Common name	Latin name	Site				Total
		1	2	3	4	
Eurasain otter	*Lutra lutra*	9	12	-	-	21
Grey Wagtail	*Motacilla cinerea*	-	73	-	1	74
Dipper	*Cinclus cinclus*	-	44	-	-	44
Blackbird	*Turdus merula*	-	5	1	8	14
Mallard	*Anas platyrhynchos*	-	2	1	-	3
Rat	*Rattus*	1	2	2	9	14
Dunnock	*Prunella modularis*	-	-	-	2	2
Long-tiled tit	*Aegithalos caudatus*	-	-	-	1	1
Great tit	*Parus major*	-	-	-	1	1
Dusky moorhen	*Gallinula tenebrosa*	-	-	-	1	1
American mink	*Neovison vison*	1	-	-	-	1
Wren	*Troglodytidae*	-	1	-	-	2
Willow warbler	*Phylloscopus trochilus*	-	-	-	4	4
Robin	*Erithacus rubecula*	-	4	-	36	40
Wood pigeon	*Columba palumbus*	-	7	-	-	7
Heron	*Ardea cinerea*	-	1	-	-	1
Song Thrush	*Turdus philomelos*	-	2	-	-	2
Collard Dove	*Streptopelia decaocto*	-	1	-	-	1
Unidentified Bird	N/A	-	3	-	17	20
Unidentified Mammal	N/A	-	-	-	1	1
Total		11	157	4	81	254
Shannon-weiner Diversity Index		**0.57**	**1.71**	**1.06**	**2.27**	
Mean temperature (°C)		**4.35**	**6.39**	**3.2**	**6.15**	

The results of the Shannon-Weiner diversity index are also shown here. The largest diversity was observed at the Estate site at 2.27, followed by the Pyramid Rock at 1.71. The McDonalds site had a diversity index of 0.57 and the Large Rock site had a diversity of 1.06.

Table 3. Ethogram of behaviours observed from camera trap footage for all species.

Behaviour	Description
Investigating	Animal sniffs, and inquisitively moves around environment
Locomotion	Animals walks, runs or wades
Grooming	Ruffling feathers, preening or washing
Alert	Perched and/or vigalent
Foraging	Searching in water for food
Defacating	Otters sprainting and any excremental discharges from any animals.

The ethogram in Table 4. shows the observed behaviours identified for all species present. Investigatory behaviours only applied to otters while grooming only applied to bird species. Foraging behaviour was only seen in dippers and accounted for 36% of all visits. Locomotion was applicable to all taxa and defecating behaviour was seen in otters and birds and as was being alert.

From Figure 3. the most commonly occurring species was grey wagtail (*Motacilla cinerea*), followed by dipper and robin which are nearly on par. The majority of visits were recorded at the Pyramid Rock site in purple, followed by the Estate site in red. Rat and blackbird cover the most sites but have the least abundance overall. Otter is nearly equal but slightly more prevalent at the Pyramid rock site the McDonalds but is by far the most common species at the McDonalds site. It is clear from this graph that abundance and distribution of the 6 dominant species vary along this stretch of river and for the majority of species (robin, grey wagtail, dipper and otter) one site seems to be favoured over the others. The mean temperatures of visits for all species vary slightly. The Large Rock site had the lowest on average temperature at visits of 3.2°C while the McDonalds site was warmer at 4.35°C followed by 6.15°C and 6.39°C for the Estate and Pyramid Rock respectively.

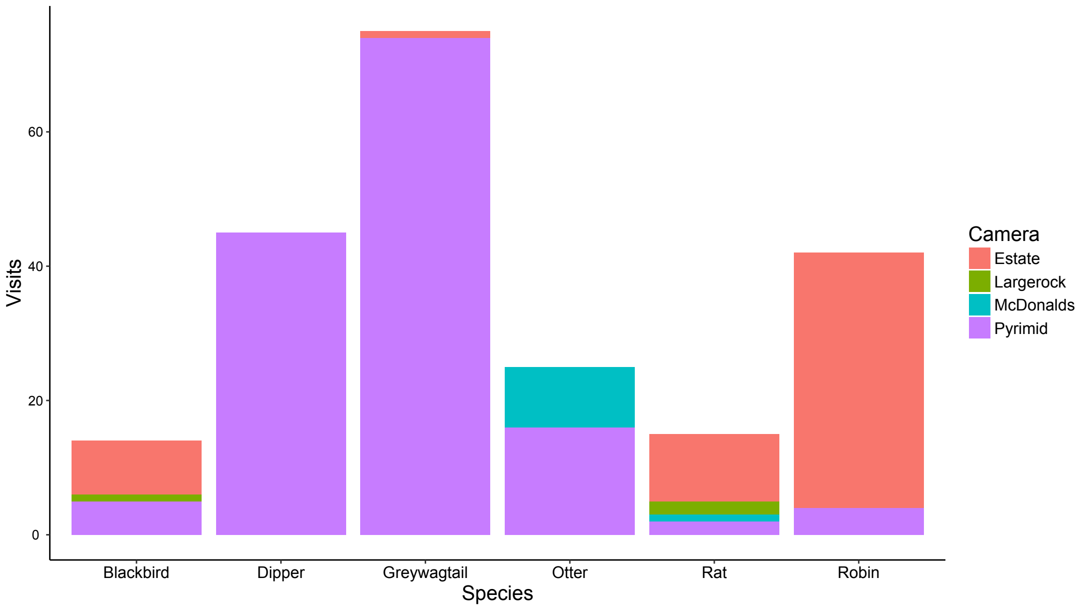

Figure 3. Bar chart showing the total number of visits by each species for the four different sites.

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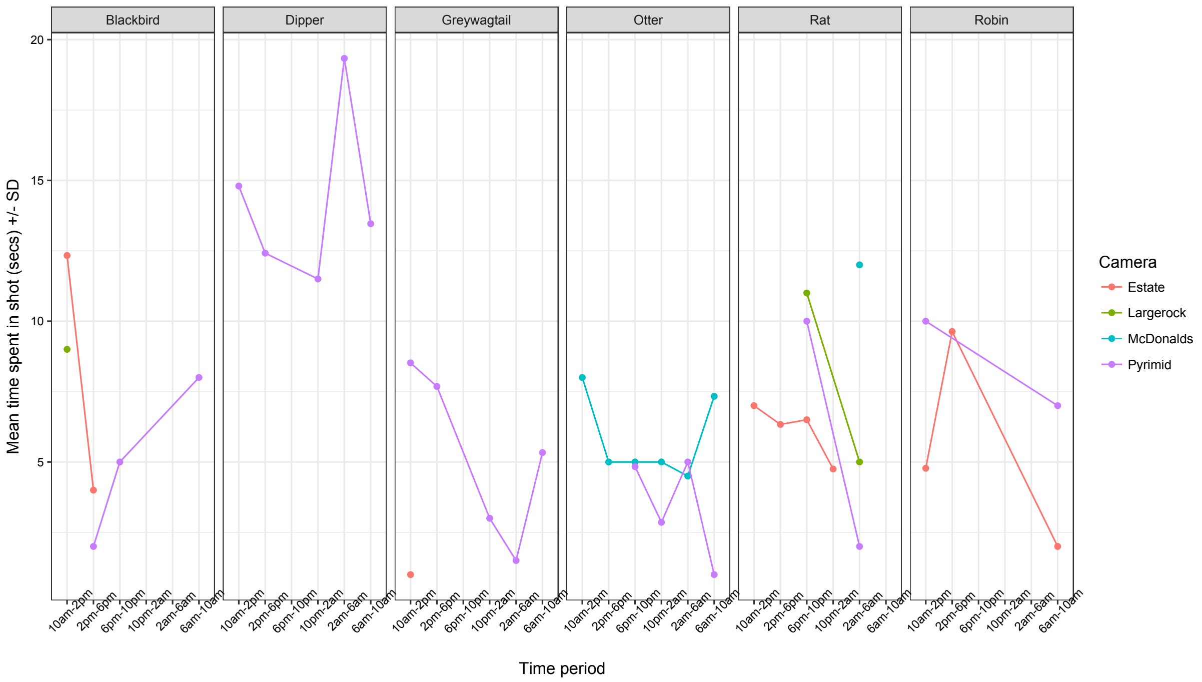

Figure 4. Plot showing the mean time spent in shot for the 6 time periods at each of the four sites for the 6 dominant species.

Figure 4. shows the where the 6 dominant species in each site, spent most of there time for the 6 time periods. Blackbirds spent longer in the Estate site earlier in the day, between 10 am - 2 pm and preferred the Pyramid Rock for the remainder of the time. Dipper was only present at the Pyramid Rock site and spent a considerably large amount of time there compared to the other species. It was present at this site for all time periods except from 6 pm - 10 pm spending the most amount of time there during the time period of 2 am - 6 am for an average of 19 seconds and the shortest amount of time there from 10 pm - 2 am at approximately 12 seconds. From figure 1 it was seen that the Pyramid Rock site was by far preferred by grey wagtails which figure 2also supports as they are present in 5 out of 6 time periods also similar to the dipper is absent from 6 pm - 10 pm and peaks at 8 seconds from 10 am - 2 pm and is lowest with 1 seconds for the appearance at the Estate. Otters were present in two sites in similar numbers (Pyramid rock = 13, McDonalds = 10) however more time was spent in the McDonalds site where visits were recorded during all time periods for mean times between 5 - 8 seconds with a peak for time periods 6 am - 10 am and 10 am - 2 pm. At the Pyramid rock site otters were present for the 4 time periods between 6 pm and 10 am for between 5 and 2 seconds. Rats were present in all sites but seemed to prefer the Estate where they were present during 4 time periods compared to 2 for the Large Rock and Pyramid Site. The longest time

was spent at the McDonalds site however where rat was only present once for 12 seconds. Lastly, robin was present at the Pyramid rock site and the Estate site. More time on average was spent at the Pyramid rock from 10 am - 2 pm, and mean time in shot was also relatively high from 6 am - 10 am. The Estate site, however, had a much larger amount of robin visits over 3 time periods, 10 am - 2 pm, 2 pm - 6 pm and 6 am - 10 pm for average times of 5, 10 and 3 seconds respectively.

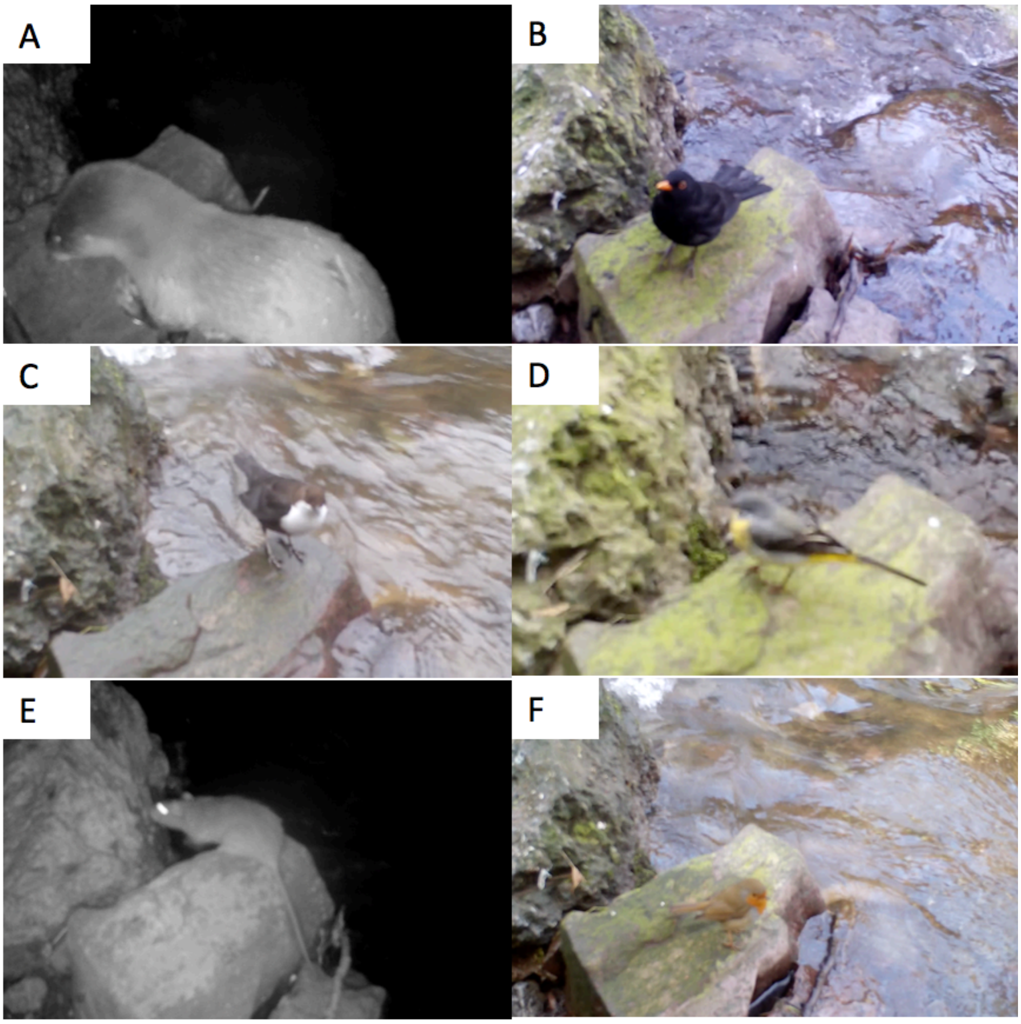

Figure 5. Screenshots from camera trap footage of the 6 dominant species - A Eurasian Otter *Lutra lutra*, B Blackbird *Turdus merula*, C White-troated Dipper *Cinclus ciclus*, D Grey wagtail *Motacilla cinerea*, E Rat *Rattus* spp., F Robin *Erithacus rubecula.*

The quality of images taken from videos can be seen in Figure 5. Species are highly distinguishable for the most part. All screenshots are from the Pyramid rock site as these were if the best angle and camera view. (WC 1514)

Discussion

The usefulness of camera trapping is commonly debated in the literature (Lerone, et al., 2015), (Lerone, et al., 2011), (Meek, et al., 2015) and there remains a need for improved methodologies (Caravaggi, et al., 2017) and a knowledge gap regarding the functioning of PIR triggered cameras (Welbourne, et al., 2016). In particular several issues have been raised in the quality of data from camera trapping otters (Stevens, et al., 2004), (Hönigsfeld-Adamič & Smole, 2011). Along with the difficulty in surveying otters and other semi-aquatic mammals is the increasing urbanisation causing habitat destruction and fragmentation. Without basic knowledge of species ecology, abundance, behaviour and habitat use conservation effort can prove futile. Flood protection directly influences otter lifestyles, however, there is a lack of mitigation measures and a lack of care taken during construction and planning to facilitate local species. The aims of the study were met in that results regarding otter behaviour and activity were identified, mitigation measures put forward and overall camera trapping thoroughly assessed.

Four camera traps were set out on an urban river prior to a drainage scheme in order to investigate otter presence and outline the usefulness of camera trapping for the species. The camera traps allowed for constant surveillance of the river and successfully identified otter presence/absence, activity patterns and behaviours. It was found that this area is important for otters to carry out their lifestyles with sprainting and locomotion occurring at 2 sites. Similar results were found in a previous study of surveying otter signs which identified 3 sprainting sites and 2 resting places on the River Bride. In this study most evidence of otters was found in close vicinity to cover (Sleeman & Moore, 2005) which was true for one site here (Pyramid Rock) however the other site (McDonalds) wasn't close to any substantial cover, however otters are also known to spraint on prominent features sch as under bridges (Kruuk, 2006) which is where the McDonalds site was. Sprainting is considered to signal resource use such as nearby feeding grounds or holts (Kruuk, 1991), in particular, feeding grounds in the form of pools (Remonti, et al., 2011) which there was one of in close vicinity to the site. This therefore could be a a potentially important feeding ground. Several non-target species were seen, which was expected, including several birds such as wood pigeons that were found in the study sites (O' Sullivan, 1994) along with *Rattus.* These species prey items of otters in Ireland (O'Leary, et al., 2006) and in this catchment (O' Sullivan, 1994).

Otters here were mostly nocturnal which was expected and is the norm (Quaglietta, et al., 2018). Most visits were recorded between 6pm-10am and again at 6am-10pm, with two distinct peaks overall. One between 6-7am just before dawn and another between 7-8am just after dusk, this is also in keeping with previous studies such as (Findley, et al., 2017). However, they seemed to prefer the Pyramid rock site just before dawn. On average per visit, more time was spent at the McDonalds site probably due to the sprainting behaviour exhibited by otters in that they approach a possible area investigate it and then spraint as suggested in previous previously (Kruuk, 2006) whereas the dominant behaviour in the Pyramid rock site was locomotion indicating an important corridor of movement along the river where often otters just moved through the frame without stopping.

Several inferences were also made regarding non-target species. Most camera trapping studies have been carried out on mammals (Meek, et al., 2015) (Rowcliffe, 2017) such as large cats (Wegge, et al., 2004) but this study shows it can also be used to investigate birds in riparian habitats if cameras are positioned correctly. It was established that the Estate site was highly likely within one robins territory, as robins are territorial (Cuadrado, 1997) and were seen on numerous occasions. Also white-throated dippers (*Cinclus cinclus*) like robins are territorial in Ireland (O' Halloran, et al., 2000) and used the Pyramid Rock site for feeding. They have been shown to spend more than half of their daily activity feeding (Bryant & Tatner, 1988). It feeds exclusively on water species and nests close to the water (Øigarden & Linløkken, 2010). Camera trapping could, therefore, be used to establish bird territories if sufficient identification techniques were identified. It has proved to be useful in identifying bird territories in particular when used with other techniques for Great Argus Pheasants (*Argusianus argus*) proving it was extremely territorial (Winarni, et al., 2009).

During the literature review, several limitations were encountered and taken into consideration during the study design such as the likelihood of theft, flooding and introducing bias. Flooding did prove to be a problem like it has in other studies (Gonza´lez-Esteban , et al., 2004) and here two camera traps became inoperable, however, this is always a risk in particular during winter and caution should be taken to monitor weather conditions in camera trapping studies. Flooding can also prevent camera maintenance increasing the chances of battery depletion, storage issues or the camera systems becoming unstable. This was true for the Estate site. Another issue found with camera trapping is that of false positives causing wasted memory, battery and research time (Findley, et al., 2017). The Estate site was where most false positives were seen per unit time (n=27 in 21 days). This is possibly due to the camera being attached to a relatively unstable branch which is attributed to increased false negatives (Swann, et al., 2004) and received no maintenance visits due to flooding. Identification was affected by camera trap angle in the Estate site which had a large number of unidentifiable birds, nearly all of these weren't identified as they weren't sufficiently in view due to being perched on a branch running parallel to the camera's view meaning a very small amount of the bird was in shot. Camera angle has been shown to affect the quality of data for mammals affecting detection rates (Meek, et al., 2015). Study duration must also be taken into account to increase sample size. This depends on the design of the study, species involved among other things i.e. whether the study is to identify habitat use or simply presence/absence (Findley, et al., 2017). For elusive species such as an otter, a larger study time is required to yield the same data for a common species seen here such as a dipper. The study period here of 61 days yielded 24 visits from otters, in comparison Lerone et al 2013 found no otters for a study period of 171 while Guter *et al* 2008 found 48 visits out of 59 camera trapping nights and a similar study with European mink, *Mustela lutreola* which used 616 cameras for a period of 7 days found 18 mink (Meek, et al., 2015). Lastly, a limitation suggested in previous studies regarding missing events for example when an otter is seen on camera leaving a holt but was not seen entering (Findley, et al., 2017), this has been attributed to the limited heat footprint of a wet otter (Kuhn & Meyer, 2009). There was no reason to believe that occurred in this study however it is worth mentioning that the number of actually visits to the sites could have been larger.

This study should be seen as the beginning of a larger study into the overall impact or drainage schemes on urban riparian ecosystems and allows for a comparison to future research. Along with that this study aimed to provide mitigation measures for during and after construction. Ideally all negative effects would be avoided but in this case the flood works are undoubtedly going ahead and therefore mitigations measures are the next step. The Office of public work identified no otters holts within the area during their surveys (Hanley, 2015) however more study is recommended here due to the number of otters signs in this study. Government bodies and environmental organisations provide several guidelines for the treatment of otters and mitigation of negative effects such as (Natural England and Department for Environment, Food & Rural Affairs, 2014)and (MulkearLIFE, 2015). These measures include not carrying out work during peak time, building barriers to stops otters accessing dangerous areas, building artificial holts and putting in otter ledges on culverts. There is evidence that artificial holts aren't highly used by otters (Jo, et al., 2006). Scientific studies to the actual value of these measures remain scarce and there is much need for longitudinal studies to investigate the impact these schemes have on otters. Construction has been shown to directly affect otter presence and breeding (Pedroso, et al., 2014), however otters will survive and use heavily modified areas like canals however with the building of a canal or in this case a culvert breeding sites in the area and resting sites are non-existent (Kloskowski, et al., 2013). Otters are efficient at recolonizing areas that previously underwent habitat degradation in that they will recolonized areas where they have been forced to leave and are in a worse condition then previously (Chanin, 2003) which is hopeful for mitigation schemes and management plans. A larger camera trap study on the river should be carried out to identify more important areas such as the possible feeding area at the Pyramid Rock site. While there is hope for mitigation measures the welfare of the otters will ultimately be damaged by the culvert and other proposed measures. (WC 1564)

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